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DOI: https://doi.org/10.1159/000356398

Original Paper

Psychopathology

Psychopathology 2014;47:235–243
DOI: 10.1159/000356398

Received: April 15, 2013
Accepted after revision: October 18, 2013
Published online: January 9, 2014

Insufficient Coping Behavior under Chronic Stress and Vulnerability to Psychiatric Disorders

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Key Words
Chronic stress · Insufficient coping skills · Affective disorders · Early detection · Students

Abstract
Background: Epidemiological data indicate that 75% of subjects with major psychiatric disorders have their onset of illness in the age range of 17–24 years. An estimated 35–50% of college and university students drop out prematurely due to insufficient coping skills under chronic stress, while 85% of students receiving a psychiatric diagnosis withdraw from college/university prior to the completion of their education. In this study, we aimed at developing standardized means of identifying students with insufficient coping skills under chronic stress and at risk for mental health problems. ***Sampling and Methods:*** A sample of 1,217 college students from 3 different sites in the USA and Switzerland completed 2 self-report questionnaires: the Coping Strategies Inventory (COPE) and the Zurich Health Questionnaire (ZHQ), which assesses 'regular exercises', 'consumption behavior', 'impaired physical health', 'psychosomatic disturbances' and 'impaired mental health'. The data were subjected to structure analyses by means of a neural network approach. We found 2 highly stable and reproducible COPE scales that explained the observed interindividual variation in coping behavior sufficiently well and in a socioculturally independent way. The scales reflected basic coping behavior in terms of 'activity-passivity' and 'defeatism-resilience', and in the sense of stable, socioculturally independent personality traits. ***Results:*** Correlation analyses carried out for external validation revealed a close relationship between high scores on the defeatism scale and impaired physical and mental health. This underlined the role of insufficient coping behavior as a risk factor for physical and mental health problems. ***Conclusion:*** The combined COPE and ZHQ instruments appear to constitute powerful screening tools for insufficient coping skills under chronic stress and for risks of mental health problems.

Introduction

Epidemiological data indicate that 75% of subjects suffering from major psychiatric disorders or with a previous history of psychiatric disorders had their onset of

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illness between 17 and 24 years of age [1]. This is exactly the time when college and university students receive their higher education, thereby experiencing significant levels of chronic stress over several years. Chronic stress, however, can lead to serious health problems and can affect nearly every system of the human body, as suggested by physical, cognitive, affective and behavioral symptoms. Indeed, in a certain percentage of the general population, chronic stress raises the blood pressure, increases the risk of heart attack and stroke [2], suppresses the immune system [3] and increases the vulnerability to psychiatric disorders such as anxiety, depression or schizophrenia [4–6].

Results from general health surveys of college students differ quantitatively in a variety of ways (sample sizes, estimated rates), a fact likely to originate from selection biases due to low survey response rates in the range of 20% [7–12]. The resulting overall picture is nonetheless very similar across study sites: typically, 50% of students report psychological distress (compared with only 11% of age-matched controls from the general population), and some 30% say that chronic stress significantly affects their academic performance. Among those reporting reduced academic performance, the stress-induced burden appeared to be closely related to a pronounced lack of coping skills, which can obviously lead to things escalating in the long run [13].

As a consequence, almost 50% of these students show elevated alcohol consumption, 12% report suicidal thoughts, and 11% have already been treated for mental health problems. As to physical activity, nearly half of those students do not meet the American Heart Association Recommendations for Physical Activity in Adults with respect to moderate-intensity cardio or aerobic exercise. Given these facts, it is not really surprising that (1) 35–50% of dropout cases among students appear to be related to insufficient coping skills, and (2) 85% of students who receive a diagnosis of major psychiatric disorder withdraw from college/university prior to completion of their education [14].

In this study, the focus was placed on college/university students at early stages of their academic education. We aimed at developing standardized means of 'early' identification of freshman students with insufficient coping skills under chronic stress and at risk for mental health problems. These students might benefit from early interventions before psychiatric symptoms develop and may reach clinically relevant thresholds [15, 16]. Specifically, our study addressed the following questions: (1) the interrelationship of coping behavior and the factors 'regular exercises', 'consumption behavior', 'impaired physical health', 'psychosomatic disturbances' and 'impaired mental health'; (2) how to draw a line between risk and nonrisk cases; (3) the extent to which insufficient coping skills are influenced by sociocultural factors, and (4) the extent to which premature dropping out among students is related to insufficient coping skills.

Materials

Power analyses based on the available data suggested a sample size of 400 subjects to cover 90% of the expected empirical variance (1,500 subjects for 95%). Accordingly, our study comprised (1) a 'learning sample' of 407 college students from Pasadena, Calif., USA; (2) a second 'learning sample' of 404 university students from Lausanne (French-speaking part of Switzerland), and (3) a 'test sample' of 406 university students from Zurich (German-speaking part of Switzerland). The 3 study sites were chosen in such a way that sociocultural differences of clinical relevance could be detected. Our basic assumption was that most college and university students experience significant levels of chronic stress over several years due to tight schedules and frequent examinations. Students were recruited for this project via 2 different approaches. A 'classroom approach' was used in Pasadena, where all students of a classroom were informed about the principal goals of our project and invited to participate in the study. By contrast, in Lausanne and Zurich we used a 'random sampling approach': after a short university-wide advertising campaign, information stands were established in central, highly frequented campus areas, where study administrators sought to enroll 400 students.

All students were asked to fill out the 28-item Coping Strategies Inventory (COPE)[1] [17] (available in standardized form in 6 languages on http://www.bli.uzh.ch/Left07b.php) along with the 63-item Zurich Health Questionnaire (ZHQ), which assesses the factors 'regular exercises', 'consumption behavior', 'impaired physical health', 'psychosomatic disturbances' and 'impaired mental health' [18] (available in 6 languages on the website mentioned above). As to the question of significant fluctuations in student dropout rates over time, we analyzed the academic performance statistics of students at the University of Zurich (UZH) for the years 1995–2010 to determine, as a function of time, the proportion of freshmen who later on graduated from UZH with a master's degree. This project was approved by the ethics committee of the Canton of Zurich.

Methods

The intrinsic structure of the COPE instrument was determined by means of neural network (NN) analysis [19] (see Appendix). In particular, we searched for the optimum number of dimen-

[1] Dispositional version, in which respondents report the extent to which they usually do the things listed when they are stressed ('I usually don't do this at all'; 'a little bit'; 'a medium amount'; 'a lot').

sions that were reproducible across study sites while explaining a maximum of the between-subject variance observed. The function *crit* with free parameters N (number of dimensions/scales) and N_k (number of items that make up the k-th scale; $k = 1, 2, N$) served as the criterion for the iterative optimization that simultaneously optimized within- and between-scale association (absolute values):

$$crit = crit\left[N > 1; N_k > 1, k = 1,2,\ldots, N; \sum_k N_k = N_{items}\right]$$

$$\sum_{k=1,N} \sum_{\substack{i,j \in Wk \\ i \neq j}} r\left(xi, xj\right) = max \qquad \text{Maximization: within-scale (1)}$$

$$\sum_{\substack{k=1,N-1 \\ l=k+1,N}} \sum_{\substack{i \in Wk \\ j \in Wl}} r\left(xi, xj\right) = min \qquad \text{Minimization: between-scale (2)}$$

where r (xi, xj) denotes the absolute value of association between the i-th and the j-th item, and Wk the set of items that make up the k-th scale.

Upon completion of each optimization step, results derived from the learning sample were verified via the replication sample so that overadaptation to the local properties of each single sample could be avoided. As this algorithm does not distinguish between local and global maxima, a 'random-walk' strategy was applied, using 10,000 random permutations as start configurations for the optimization. All scales were orthogonalized by standard Gauss transformation, normalized (0 means, SD of 10), and validated by computing the correlation between the resulting scales on the one hand, and the ZHQ factors 'regular exercises', 'consumption behavior', 'impaired physical health', 'psychosomatic disturbances' and 'impaired mental health' on the other hand. We estimated empirical variances by systematically evaluating all possible n × (n – 1)/2 euclidean distances between the 'n' subjects' 28-dimensional feature vectors (the optimal resolution of subtle between-subject differences in coping behavior was the ultimate goal of our optimization).

Results

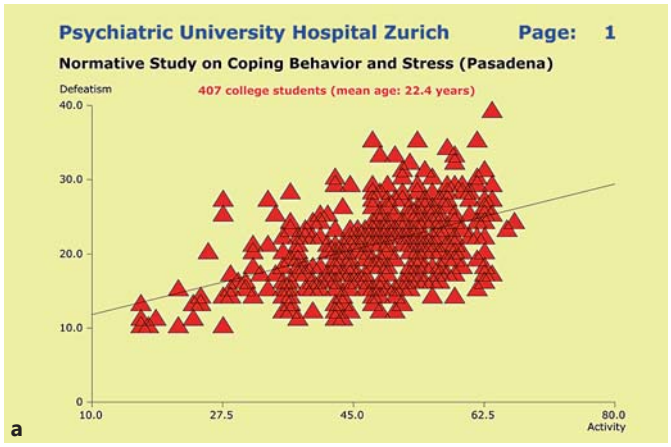
After a short advertising campaign at the study sites Lausanne (French), Pasadena (English) and Zurich (German) we were able to recruit 400 students at each site within a few days. Unexpectedly, the resulting sample compositions showed statistically significant differences between the 3 study sites with respect to gender ($p < 0.0001$): the female:male ratio was 2.1 for Lausanne, 1.2 for Pasadena and 0.85 for Zurich (table 1). If known in advance, the gender-related selection biases could certainly have been avoided; yet, as we will see later, insufficient coping skills under chronic stress turned out to be largely independent of gender, so that the gender-related biases did not at all affect the results of the structural analyses.

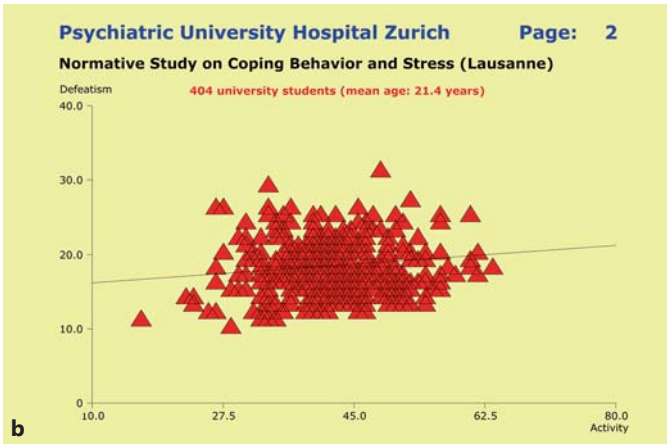
Table 1. Composition of the 3 study samples under investigation with respect to gender and age

	Total, n	Males, n	Females, n	Mean age ± SD, years
Lausanne (French)	404	130	274	21.4±3.8
Pasadena (English)	407	185	222	22.0±4.3
Zurich (German)	406	220	186	24.1±3.4

Table 2. Items underlying the new COPE scales 'activity' and 'defeatism'

Activity	
1	I've been turning to work or other activities to take my mind off things.
2	I've been concentrating my efforts on doing something about the situation I'm in.
5	I've been getting emotional support from others.
7	I've been taking action to try to make the situation better.
9	I've been saying things to let my unpleasant feelings escape.
10	I've been getting help and advice from other people.
12	I've been trying to see it in a different light, to make it seem more positive.
14	I've been trying to come up with a strategy about what to do.
15	I've been getting comfort and understanding from someone.
17	I've been looking for something good in what is happening.
18	I've been making jokes about it.
20	I've been accepting the reality of the fact that it has happened.
21	I've been expressing my negative feelings.
23	I've been trying to get advice or help from other people about what to do.
24	I've been learning to live with it.
25	I've been thinking hard about what steps to take.
28	I've been making fun of the situation.
Defeatism	
3	I've been saying to myself 'this isn't real'.
4	I've been using alcohol or other drugs to make myself feel better.
6	I've been giving up trying to deal with it.
8	I've been refusing to believe that it has happened.
11	I've been using alcohol or other drugs to help me get through it.
13	I've been criticizing myself.
16	I've been giving up the attempt to cope.
19	I've been doing something to think about it less, such as going to movies, watching TV, reading, daydreaming, sleeping, or shopping.
22	I've been trying to find comfort in my religion or spiritual beliefs.
26	I've been blaming myself for things that happened.
27	I've been praying or meditating.





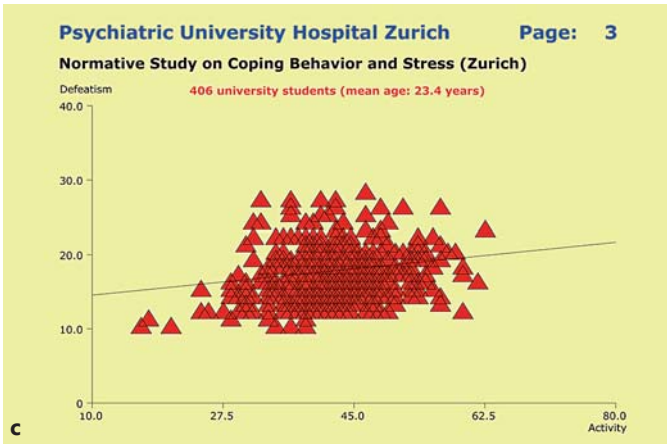


Fig. 1. Scatter plots of the raw scores 'activity' (x-axis) versus 'defeatism' (y-axis) as derived from the COPE data on 407 college students from Pasadena (**a**), 404 university students from Lausanne (**b**) and 406 university students from Zurich (**c**). There are virtually no differences between the students from Lausanne and Zurich, while the Pasadena students show a somewhat broader range of variation on the defeatism scale, along with a slightly higher correlation between the activity and defeatism scales.

As to determining the number of reproducible dimensions inherent in the COPE instrument, our NN-based structural analysis used the Pasadena and Lausanne data for iterative learning, while the Zurich data served as independent verification samples. Thus, potential site-specific sociocultural biases were avoided. We found 2 independent, highly stable and reproducible scales (factors) that explained the observed interindividual variation in coping behavior sufficiently well (68.6%: 43.8 + 24.8%). The explained variance might have been slightly increased by extracting a larger number of scales – yet at the cost of a substantial loss of stability and reproducibility across study sites. The mean within-scale correlations were, with 0.284 and 0.257, at least twice as high as the between-scale correlation of 0.127. The new COPE scales included 17 and 11 items, respectively (table 2), and reflected basic coping behavior in terms of 'activity' (activity-passivity) and 'defeatism' (defeatism-resilience). Activity is best described by items like 'turning to work', 'getting help and advice from other people' or 'coming up with a strategy', whereas 'defeatism' is characterized by behavior like 'giving up', 'using alcohol' or 'refusing to believe that this has happened'. 'Passivity' is understood as negative scoring on the activity scale, and 'resilience' as negative scoring on the defeatism scale. As the global maximum was detected by a 'random-walk' algorithm, the item-scale correlations r_{is} necessarily reflect the optimally achievable configuration for the given samples of 1,217 college students. In detail, we found $r_{is} = 0.540 \pm 0.083$ for 'activity-passivity' (range: 0.367–0.657) and $r_{is} = 0.496 \pm 0.056$ for 'defeatism-resilience' (range: 0.444–0.603). The correlation r_{ss} between the 'raw' scales was 0.260, which was subsequently eliminated by standard Gauss orthogonalization.

Even though the original between-subject variation could not be fully preserved throughout the process of scale construction, the new scales nonetheless revealed considerable interindividual variation both quantitative-

ly and qualitatively, as demonstrated by scatter plots (fig. 1a–c) where scores covered ranges of 10–70 (activity) and 10–40 (defeatism). Interestingly, we found virtually no scatter plot differences between the 404 participants from Lausanne (fig. 1b) and the 406 participants from Zurich (fig. 1c). By contrast, the scatter plot derived from the 407 Pasadena participants (fig. 1a) exhibited a slightly broader range of variation on the defeatism scale, along with a slightly higher correlation between the activity and defeatism scales (as indicated by a slightly steeper regression line).

More detailed analyses, however, showed that the differences between the USA and Switzerland on the defeatism scale were entirely eliminated by orthogonalization of the 2 scales, which makes the scales uncorrelated with each other. We found almost identical mean values on the defeatism scale across all 3 sites under investigation (0 after normalization). On the other hand, the differences on the activity scale between the USA and Switzerland remained statistically significant ($p < 0.01$): 'active' Pasadena students achieved, on average, higher activity scores, whereas no such differences were found with respect to passivity (fig. 2). All in all, our results suggest that the newly developed scales represent highly stable, socioculturally independent personality traits. While the 'defeatism-resilience' scale did not resolve any population differences between the study sites under investigation, the 'activity-passivity' scale might have revealed a small, socioculturally influenced difference between the European and the US American samples (this difference, however, could also be explained by the differences in recruitment procedure). Of particular interest is the question to what extent subjects with high defeatism scores are able to compensate this deficit through increased activity.

The factors 'alcohol consumption', 'regular use of medicine', 'illegal drugs', 'impaired physical health', 'psychosomatic disturbances', 'impaired mental health' and 'regular exercises', as quantitatively assessed by the 63 items of the ZHQ, were used to externally validate the newly constructed scales and to estimate the extent to which the new scales are related to consumption behavior and health problems. Correlation analyses yielded a highly significant and consistent picture of the close relationship between insufficient coping skills on the one hand, and the state of physical and mental health on the other hand: the higher a person's defeatism score, the higher his/her impairment in terms of physical and mental health or psychosomatic disturbances, combined with a higher consumption of illegal drugs as well as a significant lack of physical activity (table 3).

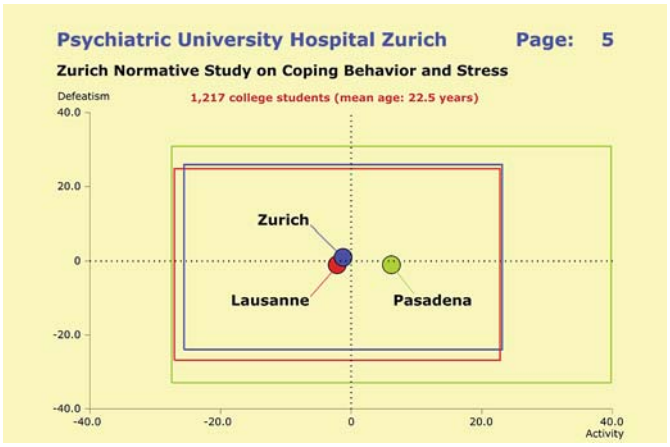


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Fig. 2. Mean scores and variation of scales 'activity' (x-axis) versus 'defeatism' (y-axis) as derived from the COPE data on 407 students from Pasadena (green), 404 students from Lausanne (red) and 406 students from Zurich (blue) after orthogonalization and normalization (colors online only). There are virtually no between-center differences with respect to 'defeatism' (0 on the y-axis), whereas active Pasadena students achieved, on average, higher activity scores than Zurich and Lausanne. No such differences were found for passivity.

Given the close association between 'defeatism' and 'impaired mental health', high defeatism scores can be regarded as a risk factor for mental health problems in the sense of an unspecific 'vulnerability'. In a first approach, we defined 'high defeatism' as ≥1.5 SD above the mean. As high 'passivity' scores might also contribute to the vulnerability to psychiatric disorders, though not as the main effect, we tentatively used this quantity as well (1 SD below the mean). We found 36 students in the Zurich sample (8.9%) to meet these criteria. It is worth noting, however, that these risk factors are neither a sufficient nor a necessary condition for the development of psychiatric disorders. In fact, no more than an estimated 10–15% of the subjects meeting the criteria will eventually receive a psychiatric diagnosis.

So far, the finding of 'sociocultural independence' is based on cross-sectional analyses of data from culturally different populations. In a further attempt to verify the notion of 'stable, socioculturally independent personality traits', we carried out a longitudinal analysis of the dropout rates among UZH students. If there were a significant sociocultural component, we should see systematic trends in dropout rates over the past 15 years, which is when the sociocultural environment of students underwent dramatic changes. Specifically, we ana-

Table 3. Correlation analyses (n = 1,217)

General health factor	Combined samples (n = 1,217)				Lausanne	Pasadena	Zurich
	passivity-activity	p	resilience-defeatism	p	resilience-defeatism	resilience-defeatism	resilience-defeatism
Regular tobacco consumption	–0.033	n.s.	0.057	0.0464	0.117	0.055	0.051
Regular alcohol consumption	–0.081	0.0046	–0.017	n.s.	0.098	0.091	0.104
Regular use of medicine	0.027	n.s.	0.101	<0.0001	0.120	0.140	0.126
Illegal drugs	0.058	n.s.	0.154	<0.0001	0.122	0.229	0.152
Impaired physical health	0.006	n.s.	0.150	<0.0001	0.202	0.115	0.124
Psychosomatic disturbances	0.051	n.s.	0.270	<0.0001	0.351	0.322	0.245
Impaired mental health	0.045	n.s.	0.387	<0.0001	0.472	0.340	0.371
Regular exercises	0.062	0.0313	–0.162	<0.0001	–0.198	–0.083	–0.153

The correlation analyses reveal a close relationship between insufficient coping skills on the one hand, and state of general health, use of illegal drugs and lack of physical activity on the other hand. The same 'pattern of correlations' is consistently found across all study sites, i.e. in a socioculturally independent way. All this underlines the reproducibility and external validity of the newly constructed scales.

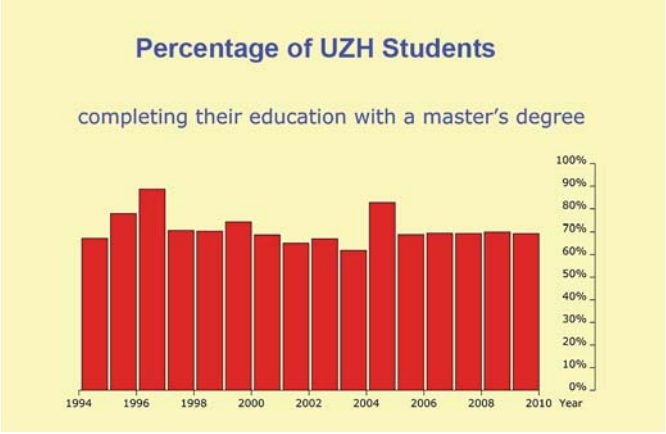

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Fig. 3. Analysis of the academic performance of UZH students for the years 1995–2010 showed an almost constant percentage of students per year who completed their education with a master's degree (70%), despite major changes in the demographic characteristics of the student population.

lyzed the academic performance of UZH students for the years 1995–2010 and determined, as a function of time, the proportion of freshmen who later on graduated from the UZH.

We found an almost constant percentage of students per year who completed their education with a master's degree (70%), despite major changes in demographic characteristics of the student population. For example, the total number of students increased, in this period, from 16,229 to 26,168 and the proportion of female students exceeded that of male students in the year 2003 (fig. 3). As a consequence, our results did not falsify the notion of 'stable, socioculturally independent personality traits'.

The statistics of students who sought psychological support in this period let us conjecture that approximately one third of premature withdrawals might be due to insufficient coping skills under chronic stress. This latter question, however, can only be reliably answered through a specifically designed prospective study.

Discussion

Based on a sample of 1,217 students from 3 different study sites, we aimed at detailing coping behavior among students under chronic stress. In particular, we were interested in (1) the interrelationships between coping skills and the general health factors 'regular exercises', 'consumption behavior', 'impaired physical health', 'psychosomatic disturbances' and 'impaired mental health'; (2) the extent to which insufficient coping skills are influenced by sociocultural factors; (3) the development of standardized means enabling the 'early' detection of freshman students with insufficient coping skills under chronic stress and at risk for mental health problems, and (4) the extent to which premature dropping out among students are caused by insufficient coping skills.

Our data on the 1,217 students from Lausanne (French), Pasadena (English) and Zurich (German) suggest the existence of 2 highly stable, socioculturally independent personality traits – 'activity' (activity-passivity) and 'defeatism' (defeatism-resilience) – which enabled quantification of basic coping behavior in a reproducible way across study sites. This is somewhat in contrast to earlier studies in the field, where authors reported some evidence for cross-cultural differences [20–22]. However, our analyses were based on much larger sample sizes. Moreover, the proposed scales were constructed via a sophisticated 'learning' algorithm in combination with stringent cross-validation techniques, thus featuring a much better resolution than earlier studies with respect to between-subject differences in coping behavior. This clearly underlines the significance of our findings as to the lack of sociocultural differences.

Interrelations between insufficient coping behavior and impaired general health have been discussed in the literature for quite a long time [13, 23–30]. Therefore, it would not seem surprising that our data revealed a close relationship between the newly constructed defeatism-resilience[2] scale on the one hand, and impaired physical health, psychosomatic disturbances and mental health on the other hand. Use of illegal drugs and lack of regular physical exercises were found to be highly significant correlates as well.

All the above-mentioned interrelations with the defeatism scale cannot necessarily be interpreted in a causal way: for example, insufficient coping skills under chronic stress might well lead to mental health problems or, reversely, mental health problems might well cause insufficient coping behavior in stressful situations. As there is increasing and consistent evidence for a high comorbidity between major psychiatric disorders and somatic conditions like hypertension, type 2 diabetes mellitus, asthma and rheumatoid arthritis, amongst others, the observed correlation between the defeatism scale and impaired physical health deserves special attention. Results from the UZH student statistics 1995–2010 support this view (fig. 3), but without yielding a definite epidemiologic estimate of the proportion of students at acute risk of developing a psychiatric disorder due to longer persisting stress periods.

As a consequence, we are planning to carry out a prospective study on 9,000 freshman students, using the combined COPE and ZHQ instruments as screening instruments, so that we will be able to focus on 'true' risk cases among the students with insufficient coping skills (no more than an estimated 10–15% subgroup will eventually receive a psychiatric diagnosis). In a second phase, these risk cases will be monitored over a 2-week period via a set of sensors throughout their regular daily life. Sensors will include speech recordings once a day along with continuous measures of heart rate, blood pressure and physical activity (accelerometer) at a 10-min resolution over 24 h. Specifically, we will be looking for well-defined events of interest, such as significant cardiovascular changes that are unrelated to physical activity.

Conclusions

The results suggest that the newly developed scales represent highly stable, socioculturally independent personality traits that quantify basic coping behavior while being closely related to physical and mental health problems among students. The method proposed appears to constitute powerful screening tools which help to identify a 10–15% subgroup of students[3] who: (1) show insufficient coping skills under chronic stress; (2) suffer an elevated risk of developing psychiatric disorders, and (3) may benefit from early intervention. Physical activity ('regular exercises') is likely to play a significant role in early intervention programs.

Acknowledgement

This project was funded in part by the 7th EU Framework Programme for Research and Technological Development (grant No. 248544; OPTIMI).

Appendix

NN approaches connect the 'neurons' of input and output layers via 1 or more 'hidden' layers (fig. 4) in such a way that the final NN model optimally predicts coping behavior scores for all subjects under investigation from their item scores. Outputs are computed using sigmoid thresholding of the scalar product of the corresponding weight and input vectors. Outputs at stage 's' are connected to each input of stage 's + 1'. NN connections are realized via (1) weight matrices and (2) model-fitting algorithms minimizing an error function in the weight space. The most popular fitting

[2] The term 'resilience' is used here as a broader concept, encompassing all those endogenous mechanisms that support and maintain health, thereby enabling patients to cope with stressful situations. This particularly includes personality traits supporting or impeding social skills [31, 32].

[3] This 10–15% subgroup is not only based on our data but also backed by estimates from the life event literature [33].

strategy, the backpropagation algorithm, looks for the minimum of the error function using the method of gradient descent. The basic algorithm is:

output: $s_i = \sigma\left[\sum_j w_{ij} s_j\right]$ y_i observed $(i = 1,2,\ldots N_i)$ (1)

hidden layer: $s_j = \sigma\left[\sum_k w_{jk} s_k\right]$ $(j = 1,2,\ldots N_j)$ (2)

input: $s_k = x_k$ x_k observed $(k = 1,2,\ldots N_k)$ (3)

improvements:

$$\Delta w_{ij} = \alpha \cdot \varepsilon_i^v \cdot s_j \cdot s_i \left(1 - s_i\right) \qquad \varepsilon_i^v = y_i^v - s_i^v \qquad (v = 1,2,\ldots p)$$

$$\Delta w_{jk} = \alpha \cdot \sum_{i=1}^{N_i} \varepsilon_i^v \cdot s_k \cdot s_i \left(1 - s_i\right) \cdot w_{ij} \cdot s_j \left(1 - s_j\right)$$

where x_k denote observed stimuli (each subject's item scores), y_i observed responses (each subject's coping behavior scores), σ the activation function of sigmoid type: $R \rightarrow (0, 1)$, α the learning rate, and p the number of subjects.

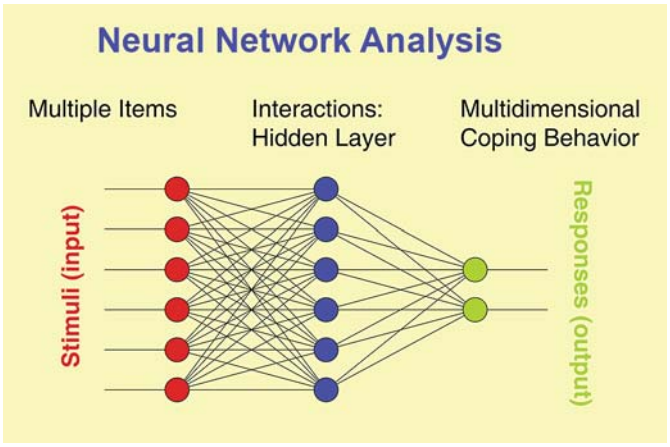

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Fig. 4. NN approaches connect the 'neurons' of input and output layers via 1 or more 'hidden' layers in such a way that the final model optimally predicts coping behavior scores for all subjects under investigation from their item scores.

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